

the employment of sulphurous acid, by giving the gas time to cool after compression. M. Cailletet has not yet obtained, at all events, so far as we yet know, oxygen in a liquid form, as M. Pictet has done; on being separated from its enormous pressure it has merely put on the appearance of a cloud.

M. Pictet's arrangements are more elaborate. He uses four vacuum- and force-pumps, similar to those which were recently exhibited in the Loan Collection of Scientific Apparatus for making ice, driven by an engine of 15-horse power. Two of these are employed in procuring a reduction of temperature in a tube about four feet long containing sulphurous acid. This is done in the following way: the vacuum pump withdraws the vapour from above the surface of the liquid sulphurous acid in the tube, which, like all the others subsequently to be mentioned, is slightly inclined so as to give the maximum of evaporating surface. The force-pump then compresses this vapour, and sends it into a separate reservoir, where it is again cooled and liquefied; the freshly-formed liquid is allowed to return under control to the tube first referred to, so that a complete circulation is maintained. With the pumps at full work there is a nearly perfect vacuum over the liquid and the temperature falls to -65° or -70° C.

M. Pictet uses this sulphurous acid as a cold-water jacket, as we shall see. It is used to cool the carbonic acid after compression, as water is used to cool the sulphurous acid after compression.

This is managed as follows:—In the tube thus filled with liquid sulphurous acid at a temperature of -60° C. there is another central one of the same length but naturally of smaller diameter. This central tube M. Pictet fills with liquid carbonic acid at a pressure of four or six atmospheres. This is then let into another tube four metres long and four centimetres in diameter. When thus filled the liquid is next reduced to the solid form and a temperature of -140° C., the extraction of heat being effected as before by the pump, which extracts three litres of gas per stroke and makes 100 strokes a minute.

Now it is the turn of the oxygen.

Just as the tube containing carbonic acid was placed in the tube containing sulphurous acid, so is a tube containing oxygen inserted in the long tube containing the now solidified carbonic acid. This tube is five metres long, fourteen millimetres in exterior diameter, and only four in interior diameter—the glass is very thick. The whole surface of this tube, except the ends which project beyond the ends of the carbonic acid tube, is surrounded by the frozen carbonic acid.

One end of this tube is connected with a strong shell containing chlorate of potash, the other end is furnished with a stop-cock.

When the tube was as cold as its surroundings, heat was applied to the chlorate, and a pressure of 500 atmospheres was registered; this descended to 320. The stop-cock was then opened, and a liquid shot out with such violence that none could be secured, though we shall hear of this soon.

Pieces of lighted wood held in this stream spontaneously inflamed with tremendous violence.

In this way, then, has oxygen been liquefied at last.

But this result has no sooner filled us with surprise than it has been completely eclipsed. On the last day of December, a week after the meeting of the Academy to which we have referred, M. Cailletet performed a series of experiments in the laboratory of the École Normale at Paris, in the presence of Berthelot, Boussingault, St. Claire Deville, Mascart, and other leading French chemists and physicists, using the same method as that formerly employed for oxygen and he then and there liquefied hydrogen, nitrogen, and air!

M. Cailletet first introduced pure nitrogen gas into the apparatus. Under a pressure of 200 atmospheres the tube was opened, and a number of drops of liquid nitrogen were formed. Hydrogen was next experimented with, and this, the lightest and most difficult of all gases, was reduced to the form of a mist at 280 atmospheres. The degree of cold attained by the sudden release of these compressed gases is scarcely conceivable. The physicists present at the experiment estimated it at -300° C.

Although oxygen and nitrogen had both been liquefied, it was deemed of interest to carry out the process with air, and the apparatus was filled with the latter, carefully dried and freed from carbonic acid. The experiment yielded the same result. On opening the tube a stream of liquid air issued from it resembling the fine jets forced from our modern perfume bottles.

These more recent results are all the more surprising as, at an earlier stage, hydrogen, at a pressure of 300 atmospheres, has shown no signs of giving way.

These brilliant and important results, though, as we have said, they give us no new idea on the constitution of matter, open out a magnificent vista for future experiment. First, we shall doubtless be able to study solid oxygen, hydrogen, and air, and if MM. Pictet and Cailletet succeed in this there will then be the history to write of the changes of molecular state, probably accompanied by changes of colour, through which these elemental substances pass in their new transformations.

There is a distinct lesson to be learnt from the sources whence these startling *tours de force* have originated. The means at the command of both MM. Cailletet and Pictet arise from the industrial requirements of these gentlemen, one for making iron, the other for making ice.

Why then in England, the land of practical science, have we not more men like MM. Cailletet and Pictet to utilise for purposes of research the vast means at their disposal, or at all events to allow others to use them?

It is also clear that to cope with modern requirements our laboratories must no longer contain merely an antiquated air-pump, a Leyden jar, and a few bottles, as many of them do. The professor should be in charge of a work- instead of an old curiosity-shop, and the scale of his operations must be large if he is to march with the times—times which, with the liquefaction of the most refractory gases, mark an epoch in the history of science.

HUXLEY'S PHYSIOGRAPHY

Physiography: an Introduction to the Study of Nature.

By T. H. Huxley, F.R.S. (London: Macmillan and Co., 1877.)

AMONG educational works which are calculated to afford real assistance to the teacher in his all-important labours, we may recognise two distinct classes. One

of these includes the "text-books," which should aim at presenting only the accurate and well-proportioned outlines of a system of instruction, leaving it to the teacher himself so to fill in these outlines with explanation and illustration, as to cause the new facts and reasonings to produce the most vivid and abiding impressions upon the minds of his pupils. But inasmuch as the attainment of such a result demands much practical skill and educational tact—a skill and tact which are by no means easy of acquirement—the necessity and value of another class of works becomes manifest. This second class of educational works comprises such as aim at instructing the teacher how best to perform his difficult task; which exemplify the work of explanation, illustrate the art of illustration, and show how the dry bones of barren facts may, by clear arrangement and logical connection, be compacted into a body of real knowledge, and this body by being infused with the earnest intelligence of the teacher, may be quickened into active and fruitful life in the minds of the scholars.

It is to this latter very important class of educational works that we should be inclined to refer the book before us, and we cannot therefore regard the designation of it as a "manual for students," which is borne upon its cover—one for which we suspect that the author is not himself responsible—as either happy or judicious. That some instruction in the physical laws of that universe in which we are placed ought to form a recognised part of our system of elementary education has been again and again maintained and strongly insisted upon by scientific men, and by none more persistently or more urgently than by the author of the present work. When we reflect on the fact that to the man who has learnt to recognise, obey and apply these laws, Nature reveals herself as a helpful and bountiful mother, ever ready to aid him in his industry, his arts, and his commerce; while to him who ignores or violates these laws she is known only as a terribly relentless and avenging goddess, ever thwarting his most earnest endeavours, and scourging him with plagues, pestilences, and famines—it is hard to realise how slowly the necessity for this instruction in natural knowledge has forced itself upon the minds of those who are responsible for the scheme of elementary education adopted in this country. But society—the machinery of which is every day becoming more complicated and more susceptible to those painful consequences which follow from the infringement of the laws of nature—will doubtless in the end demand, as indeed it has a right to do, that every unit in her organisation should be fitted so to play his part, as to avoid the danger to himself and others which the neglect or violation of natural laws invariably entails.

Almost every demand that the principles of physical science should be taught in our elementary schools, has been met with the objection that our knowledge of nature and her laws has in recent years grown to such an extent, and ramified into so vast a number of channels as to make any attempt to teach it to the young quite hopeless. As well might we point to the number of volumes in the library of the British Museum, and declare that their existence demonstrates the uselessness of teaching the art of reading. No one, of course, would desire that an epitome all the sciences should be taught to children; but what

is demanded is that the methods of modern scientific thought should be made familiar to every mind, that a few leading and necessary truths should be taught concerning the world in which we live and the laws which control its potent forces (seeing that upon our knowledge or ignorance of these depends much of our happiness and success or our misery and failure in the adventure of life), and that, last but not least, the minds of all young people should be conducted within the threshold of the temple of natural knowledge, so that any among them that may be endowed with the necessary capabilities may learn there to dedicate themselves to the pursuit of science.

How can this elementary instruction in science be best imparted to the young? This is the important question which Prof. Huxley applies himself to answer in the work before us; and he accomplishes his object much better by means of example than he could by any amount of discussion of the general principles of the art of teaching. On several other occasions the author has indicated the importance of making a knowledge of the more striking phenomena of nature, those with which we come into contact in our every-day life, and which exercise the greatest influence on our daily occupations and experiences, the starting-point of our introduction to the world of scientific thought; and it is to this vestibule of the temple of natural science that he applies the name of "Physiography."

The author of the present work of course recognises that first principle of good teaching which consists in fastening at first on facts and ideas which are known and familiar, and from thence leading the minds of the student by a succession of steps, no one of which shall present any serious difficulties, up to those more unfamiliar observations and those less obvious deductions from them, which if presented in the first instance might startle and repel rather than attract the scholar. We must ask the reader himself to trace in the work before us how, setting out from the most striking and easily observed facts about the River Thames, Prof. Huxley shows his admirable skill in teaching by leading his readers through a series of reasonings couched in simple and untechnical, but always accurate and elegant, language, up to the grandest truths in physics, biology, geology, and astronomy; how, throughout, happy analogies and telling illustrations make the path of the scholar, light, easy, and pleasant; and how in all this nothing of the exactness and dignity of science is sacrificed to a desire to say those fine or funny things which are too often supposed to convert a prosy book into a "popular" one.

The teacher who takes these easy lessons in elementary science and simply repeats them to his scholars can scarcely fail to communicate some sound and useful instruction to them. But every competent and judicious teacher will prize Prof. Huxley's book rather as a model than as a "crib"—and this is the light in which the author, we are persuaded, would desire that his work should be regarded by them. It is as easy, for example, to make the Mersey, the Severn, the Forth, or the Clyde the starting point of our studies of nature, as the Thames, and in Manchester, Bristol, Edinburgh, or Glasgow respectively, it is far better to do so; nor will any well-instructed teacher find the smallest difficulty in thus adapting his lessons to his

auditory. To such teachers as have never studied or thought on scientific questions themselves, our advice would be to content themselves with placing Prof. Huxley's book in their school-libraries, and not to run the risk of spoiling its teachings by filtering them through their own minds.

We have spoken at such length on the value of this work to the teacher, as to leave but little space for reference to its interest to the general reader, yet this is by no means small; to those who seek an "introduction to the study of nature," which shall be at the same time both sound and readable, exact and untechnical, we most heartily commend the work before us.

We are informed in the preface that the idea of this work has long been entertained, and its plan and methods frequently revolved in the mind of the author. It is probable that not a little of its present excellence is due to this slow maturation of its plan, assisted, as we learn that its development has been, by its embodiment in two successive courses of lectures—on the shorthand notes of one of which the present book is based. In seeking for an editor to relieve him of the more trying labour of book-making, Prof. Huxley has been fortunate in securing the services of Mr. Rudler, whose knowledge of a great number of branches of science is combined with much literary skill. To this cause we may attribute the small number of inaccuracies in either fact or expression which a careful perusal of the work has revealed. Such as do occur may be easily remedied in the new edition, which we have no doubt will soon be called for.

In concluding this notice we cannot refrain from congratulating its author upon the production of the work, and at the same time of assuring him that among all the labours he has undergone, and the sacrifices he has made on behalf of elementary education in this country, none is likely to produce more valuable and more enduring fruit than this much-needed model of the art of teaching the fundamental truths of natural science, the appearance of which at the present time we cannot but regard as being most opportune.

J. W. J.

OUR BOOK SHELF

Myths and Marvels of Astronomy. By Richard A. Proctor. (London: Chatto and Windus, 1878.)

THE author observes in his preface that "the chief charm of astronomy with many does not reside in the wonders revealed to us by the science, but in the lore and legends connected with its history, the strange fancies with which in old times it has been associated, the half-forgotten myths to which it has given birth," and further remarking that in our own times myths and fancies, startling inventions and paradoxes have also found place, he has framed the present volume to meet the tastes of the class of readers which he believes to be specially interested in such matters.

In a work confessedly written with this object in view, perhaps it will hardly be expected that there can be much to require notice in a scientific journal. An important point will be accuracy of detail, and in this respect, except in two or three cases, we remark little to which exception can be taken. Amongst other subjects, the author enters upon "the religion" and the mysteries of the Great Pyramid, "Suns in flames," the rings of Saturn, comets as portents, the notorious lunar-hoax of 1835-36, and the origin of the constellation-figures. He

is unlucky in his notice of the first discovery of the famous star of Tycho Brahe in 1572, reproducing from Sir John Herschel's "Outlines," the story of Tycho's attention having been first directed to the object on the evening of November 11, by seeing "a group of country people gazing at a star which he was sure did not exist an hour before." This story is as much a myth as anything in the volume before us, as will be evident to the reader who consults the account of his first observation and of the observations of others given by Tycho himself, and it is strange that the statement which has misled Mr. Proctor should have been continued in the various editions of Sir John Herschel's "Astronomy" since the year 1833. The account given in the chapter "On some Astronomical Myths" of the actual position of the intra-Mercurial planet question is too incomplete to enable the reader to form a competent judgment thereupon, though it may leave him under the impression that there is something mythical about it. Mr. Proctor appears to reject "the idea of wilful deception" on the part of astronomical observers—in which case the mere expression of disbelief in the existence of an intra-Mercurial body or bodies does not assist explanation of recorded observations, more particularly where motion has been remarked. There are a few numerical errors in the volume, as in the note on p. 235, where it is stated that the comet of the August meteors has "a period of at least 150 years;" so long a period would be irreconcilable with the observations, and the very complete investigation by Prof. Oppolzer assigns 121½ years as the most probable length of the revolution. But as already stated there is general accuracy of detail, and the volume will doubtless be found acceptable to the particular class of readers for whom it has been prepared.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.]

The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

Electrical Experiment

THE inclosed letter gives an account of an experiment in which an electric current appears to be produced by the direct action of gravity, a result which, if clearly established, would be new and of considerable scientific interest.

In trying to repeat the experiment yesterday I observed a considerable deflexion of the galvanometer in the direction described by Mr. Pirani, but as this deflexion seemed to occur some seconds after the inversion of the tube, I examined the tube and found a small bubble of air working its way up through the solution, and as soon as it came to the top of the tube the deflexion occurred.

I have not yet had time to repeat the experiment without the bubble, but I mention this to show that care must be taken to secure that the electrolyte is homogeneous, and that it does not contain anything which will either sink to the bottom of the tube or float to the top, so as to act alternately on the two electrodes.

The fact that the deflexion continued for some time after the tube was placed horizontally seems to indicate the possibility of something which was shifted from end to end when the tube was inverted, but remained where it was when the tube was only laid on its side.

J. CLERK MAXWELL

Cavendish Laboratory, Cambridge, December 28, 1877

"University of Melbourne, Oct. 30, 1877

"MY DEAR SIR,—On page 317 of vol. i. of your 'Electricity and Magnetism' it is pointed out that a greater electromotive force is required to produce a given current between zinc electrodes in a solution of sulphate of zinc when zinc is carried upwards than when it is carried downwards.

"I am not aware that it has been noticed that by the same